# A new shallow water species of *Nucinella* from the Philippines (Bivalvia: Protobranchia: Nucinellidae), member of a tropical seagrass chemosynthetic community

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## ABSTRACT

A new species of the protobranch bivalve *Nucinella* is described from Panglao, central Philippines. It lives in very shallow seagrass habitats and co-occurs with other chemosymbiotic lucinid bivalves *Pillucina* and *Cardiolucina*. The species has been included in recent molecular phylogenies. For comparison details of hinge teeth are provided for the type species of *Nucinella*, *Pleurodon ovalis*, from the Pliocene of England.

*Additional Keywords:* protobranch, chemosymbiosis, new species

## INTRODUCTION

Nucinellidae is a family of minute, mainly deep-water protobranch bivalves recently recognised as chemosymbiotic (Oliver and Taylor, 2012; Bieler et al., in press). Unusually, they are also all monomyarian, with only the anterior adductor muscle present. There are 21 known species in two genera comprising 15 *Nucinella* and 6 *Huxleyia* (La Perna, 2005; Oliver and Taylor, 2012). Identification of *Nucinella* is problematic on account of their small, smooth, external shells and species discrimination is largely based on hinge dentition and ligament form. Most are <5mm in height, with ovoid, smooth shells, often with a blue-green periostracum; the largest living species (25 mm) is *Nucinella boucheti* La Perna, 2005 described from 1600 m in the Philippines (La Perna, 2005). The ligament is external, either opisthodetic or amphidetic in *Nucinella* and internal opisthodetic in *Huxleyia*. The dentition is taxodont with up to 13 teeth located beneath the umbones and a larger and generally elongate, single anterior lateral tooth. There are persistent reports that *Huxleyia* species are dimyarian (e.g. Coan and Scott, 2012) but, after careful examination of several species, Oliver and Taylor (2012) were unable to confirm this and considered the genus monomyarian, as did Hayami and Kase (1993). Anatomically, nucinellids have large protobranch ctenidia, a large cleft foot that is deeply digitate at the margins and small, finger-like labial palps (Allen and Sanders, 1969; Kuznetsov and Schilyeko, 1984; Oliver and Taylor, 2012).

The depth distributions of living nucinellids are known to range from the interidal zone to 3580 m (Matsukuma et al., 1982; La Perna 2005; Oliver and Taylor, 2012) although the majority of records are from offshore to bathyal depths with *N. owenensis* Oliver and Taylor, 2012 found at 3400 m off Oman. Only a few species are known from very shallow water; *Huxleyia diabolica* (Jousseaume, 1897) is recorded from 6–40 m in seagrass and sand habitats of the northern Red Sea (Zuschin and Oliver, 2003) and *Huxleyia cavernicola* Hayami and Kase, 1993 is abundant in shallow sublittoral submarine caves of the Ryukyu Islands (Hayami and Kase, 1993). *Nucinella woodii* (Dall, 1898) lives in the Florida Keys at subtidal depths, 65 to 188 m (R. Bieler personal communication).

Reid (1990) speculated that nucinellids might be chemosymbiotic and the presence of bacterial symbionts in the ctenidial leaflets was later confirmed morphologically for two Indian Ocean species (Oliver and Taylor, 2012), by isotopic analysis of a New Zealand fjord species (McLeod et al., 2010) and the symbiotic Gammaproteobacteria identified molecularly (Bieler et al., in press) for *Nucinella giribeti* new species, described herein. Fossil monomyarian nucinellids, morphologically similar to living species, are recognized from the early Jurassic where they are often associated with dysaerobic environments (Harries and Little, 1999) and others reported from Mesozoic hydrocarbon seeps (Amano et al., 2007), with the likelihood that they were also chemosymbiotic.

The relationship of Nucinellidae to other protobranchs is still uncertain. Despite large morphological differences in the shells Allen and Sanders (1969) suggested a close relationship with Solemyidae on the basis of anatomical similarity. Pojeta (1988) claimed a descent from Palaeozoic "solemyoideans" through the dimyarian *Manzanella* from the Permian. Since then nucinellids have been classified in the superfamily Manzanelloidea in the Solemyida, usually as the family Manzanellidae (Bieler et al., 2010). For reasons discussed in Oliver and Taylor (2012) we use the family name Nucinellidae for *Nucinella* and *Huxleyia* rather than Manzanellidae, which is based on the dimyarian Permian fossil *Manzanella* (Chronic, 1952). Recent molecular results provide little or no support for the monophyly of Solemyidae +Nucinellidae (Bieler et al., in press; Sharma et al., 2013).

We describe this new species from the Philippines, firstly, because it is one of the few *Nucinella* known from very shallow water and secondly, because it has been included in molecular and morphological analyses of bivalve phylogeny recorded only as *Nucinella* sp. (Bieler et al., in press, Sharma et al., 2013). The other nucinellid included in molecular analyses is *Huxleyia munita* (Dall, 1898) from the northeastern Pacific.

## MATERIALS AND METHODS

*Nucinella* shells were collected in the Philippines during the Panglao 2004 Marine Biodiversity Project (see Bouchet et al., [2009] for details). They were found in a bulk sample collected by suction air-lift (station S11) and another single live-collected specimen from station S39 was used for molecular analyses by Bieler et al (in press).

Specimens were examined using Philips XL30 and FEI Quanta 650 scanning electron microscopes (SEM) following sputter coating in Au/Pd.

Institutional abbreviations used: MCZ, Museum of Comparative Zoology, Harvard University, Cambridge, USA; MNHN, Muséum National d'Histoire Naturelle, Paris, France; NHMUK, Natural History Museum, London, U.K. Other abbreviations: H, height; L, length, PI, protoconch 1. All shell measurements in millimeters.

## SYSTEMATICS

Subclass Protobranchia
Superfamily Manzanelloidea Chronic, 1952
Family Nucinellidae Vokes, 1956

**Description:** Shell obliquely oval, mostly higher than long. Hinge with sub-umbonal taxodont teeth and single, usually elongate lateral tooth on the anterior dorsal margin. Ligament mostly opisthodetic, wholly external or in a sunken resilifer. Shell sculpture of fine commarginal lirae; periostracum often glossy, persistent, rather thick. Monomyarian, only anterior adductor muscle present. Anatomy protobranch with large ctenidia (Allen and Sanders, 1969; Kuznetsov and Schileyko, 1984; Oliver and Taylor, 2012).

**Remarks:** The main difference between *Nucinella* and *Huxleyia* is the position of the ligament, external or slightly sunken in the former or wholly internal in the latter. For *Nucinella*, Oliver and Taylor (2012, fig. 7) showed that there is considerable variation between species in how deeply the ligament is sunken into the hinge plate.

### Genus *Nucinella* Wood, 1851

**Type Species:** *Pleurodon ovalis* Wood, 1840, non *Pleurodon* Harlan, 1831. Syntype lots NHMUK Ramsholt L4465, Sutton L4464, L4618. Features of *N. ovalis*, probable syntypes, with details of the sub-umbonal teeth are illustrated in Figures 1–5.

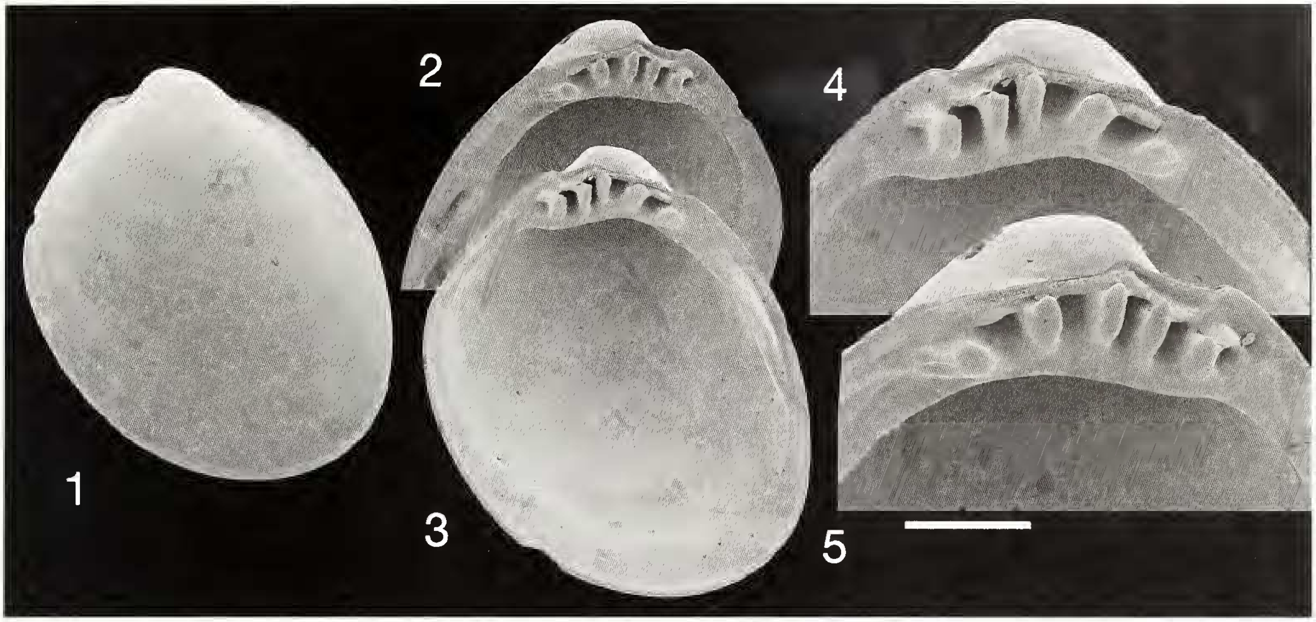
**Diagnosis:** As for the family, ligament external or in a shallow resilifer.

**Remarks:** See Vokes (1956) for details of type species designation. *Nucinella ovalis* is a Pliocene fossil first described from the Coralline Crag, Ramsholt and Sutton Members, Suffolk, England, (straddles Pliocene stage boundary of Zanclean and Piacenzian, 3.5–3.4 mya). Both localities have similar stratigraphy and the palaeoenvironment is thought to be offshore, shallow water to 50 m depth (Long and Zalasiewicz, 2011). Interestingly, *Nucinella* has been extinct since the Pleistocene in the northeastern Atlantic and Mediterranean (La Perna, 2004).

### *Nucinella giribeti* new species
(Figures 6–17)

**Description:** Shell very small, largest valve L 2.8, H 3.9 (largest live shell L 2.3, H 3.0), equivalve, outline subovoid, external surface smooth with fine growth increments only, periostracum thick, *ca.* 5 μm, greenish, shell colour white. Protoconch, PI 148 μm long (holotype), sharp boundary to post-larval shell. Ligament opisthodetic short, set in shallow resilifer. Hinge, with 5–7 sub-umbonal teeth, slightly variable in size, younger individuals may have fewer teeth (Figures 15–16). Holotype (Figures 11–14) right valve with 7 sub-umbonal teeth, blade-like, slightly larger in posterior, anteriormost tooth very small; lateral tooth prominent, short, dorsal to adductor muscle scar; left valve with 6 sub-umbonal teeth, 2 posterior larger, anteriormost very small; lateral tooth as right valve. Anterior adductor muscle scar large, ovoid, posterior scar absent. Inner shell margin smooth. Image of live animal (Figure 6) shows extended, multidigitate foot.

**Type Material:** Holotype, whole shell, MNHN 26701, Figs 11–14, 17, L 2.0 H 2.7; Figured paratypes: Three whole shells: NHMUK 20130108, L 2.2, H 2.9 (Figure 7) and MNHN 26702, L 1.9, H 2.6; L 2.3, H 3.0 (Figures 8–9); MNHN 26703, 1 right valve, L 1.5 H 2.1 (Figure 10); 2 right valves (Figures 15,16). Other paratypes, 41 paired valves, 25 valves, MNHN 26704; 5 paired valves, 10 valves, NHMUK 20130108.



**Figures 1–5.** *Nucinella ovalis* (Wood, 1840), type species of *Nucinella* from Pliocene, Coralline Crag, Ramsholt, Suffolk, England. Probable syntypes NHMUK L4465. **1.** Exterior or right valve, L = 1.5 mm. **2–3.** Interiors of right and left valves, L = 1.9 mm. **4–5.** Details of hinges of left and right valves. Scale bar = 300 μm.

**Type Locality:** Philippines, Panglao Island, lagoon off Poblacion 9°33.6′ N, 123°43.6′ E, 2 m, fine sand and seagrass, PANGLAO 2004, station S11.

**Other Material Examined:** Sequenced specimen from Philippines, Panglao Island, Tagbilaran-Panglao channel, 9°38.1′ N, 123°51.4′ E, 3–4 m, muddy sand beds of *Modiolus* sp., PANGLAO 2004, station S39. **GenBank numbers:** 18S rRNA: KC429324; 28S rRNA: KC429414; COI: KC429089.

**Habitat and Distribution:** Known only from or near the type locality in shallow water sand with seagrass.

**Etymology:** Named for Gonzalo Giribet, evolutionary biologist responsible for the first sequencing of Nucinellidae.

**Remarks:** The only other known species of *Nucinella* from the Philippines is *N. boucheti,* which occurs at depths of 1610–1580 m; this species, however, is much larger and has 13 sub-umbonal teeth (La Perna, 2005). In the tropical Indo-West Pacific three species of *Nucinella* are recorded from Japan (Matsukuma et al., 1982), a single species from off eastern Australia (Vokes, 1956), a larger species off Zanzibar (Thiele and Jaeckel, 1931), as well as the recently described *N. owenensis* from off Oman; all are from deeper water and differ in dentition from *N. giribeti*.

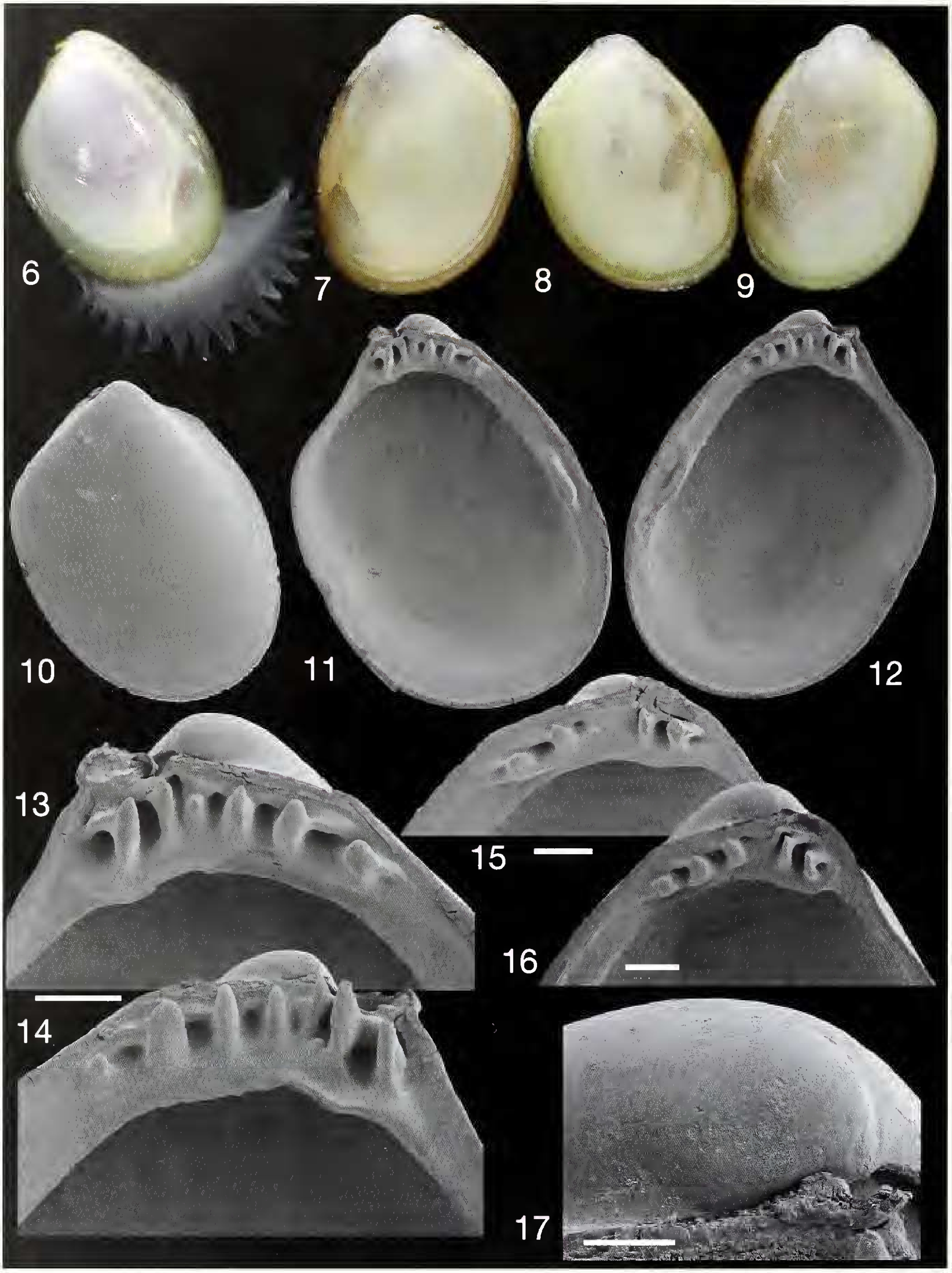
The type species of *Nucinella*, *Pleurodon ovalis* is a Pliocene fossil from the Coralline Crag of England that is similar in size and sub-umbonal dentition to *N. giribeti* but has a much longer anterior lateral tooth. (Figures 1–5).

## DISCUSSION

*Nucinella giribeti* is the only species of the genus recorded from intertidal depths and it is very surprising that there are no other records from similar habitats in Southeast Asia. In all probability they have been overlooked because of their very small size, but the discovery in Panglao indicates that they can be quite abundant. The *N. giribeti* from the type locality were associated with chemosymbiotic lucinids *Pillucina* new species and *Cardiolucina siquijorensis*, both of which occurred in abundance in the seagrass sediments (Taylor and Glover, 1997; Glover and Taylor, in press). Both stations also contained several species of cardiids including *Fragum* spp., *Microfragum* spp., and *Fulvia* sp. (ter Poorten, 2009); other bivalves have yet to be studied.

Most nucinellids, along with many other protobranch mollusks, are found in deeper water from shelf to bathyal depths, with one of the deepest so far recorded being *Nucinella owenensis* recently described from 3400 m in an $O_2$ minimum zone, associated with deposit feeding and other chemosymbiotic bivalves (Oliver and Taylor, 2012). The Japanese species *Nucinella viridis* Matsukuma et al., 1983 was found at 3581 m at a likely hydrocarbon seep (Okutani and Iwasaki, 2003; Sasaki et al., 2005).

Life histories of Nucinellidae are poorly understood, but in common with other protobranchs, they are



**Figures 6–17.** *Nucinella giribeti* new species. **6.** Live specimen, 0–3 m Panglao Island, Philippines. Image by Pierre Lozouet MNHN. **7–9.** Paratypes. **7.** Left side (NHMUK 20130108), H = 2.9 mm. **8.** Right side, (MNHN 26702), H = 2.6 mm. **9.** Left side (MNHN 26702), H = 3.0 mm. **10.** Paratype, exterior of right valve (MNHN 26703), L = 1.5 mm, H = 2.1 mm. **11–12.** Holotype (MNHN 26701), interior of left and right valves, L = 2.0 mm, H = 2.7 mm. **13–14.** Holotype, detail of hinge teeth of left and right valves. Scale bar = 200 μm. **15.** Paratype, right valve, detail of hinge to show tooth variation (MNHN 26703). Scale bar = 200 μm. **16.** Paratype, right valve detail of hinge teeth (MNHN 26703). Scale bar = 200 μm. **17.** Protoconch of right valve of holotype. Scale bar = 50 μm.

presumed to have only lecithotrophic planktonic development. Protoconch sizes are variable: the type species *N. ovalis* is at least 210 µm, *N. giribeti* is 148 µm and *N. seguenzae* (Dall, 1898) (a Pleistocene fossil from Spain) is 260 m (La Perna, 2004).

*Nucinella giribeti* and *Huxleyia munita* (Eastern Pacific) are the first nucinellids to be included in molecular phylogenies of bivalves (Sharma et al., 2013; Bieler et al., in press), with results indicating a long independent history of these bivalves separate from the Solemyoidea. The pre-Mesozoic history of the Nucinellidae is uncertain but by early Jurassic times nucinellids, similar in morphology to living forms, were present in dysaerobic sediments (Harries and Little, 1999; Wignall et al., 2005) with later Cretaceous records from hydrocarbon seeps (Amano et al., 2007) indicating the high probability of early acquisition of chemosymbiosis in the family.

## ACKNOWLEDGMENTS

We are grateful to Dr. Philippe Bouchet and his team (MNHN) for access to the *Nucinella* specimens. Pierre Lozouet (MNHN) kindly allowed us permission to publish Figure 6. We thank Alex Ball (NHMUK) for assistance with SEM, Rüdiger Bieler (Field Museum, Chicago) for details of the habitat of *Nucinella woodii*, and Liz Harper (University of Cambridge) for advice on the Coralline Crag.

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